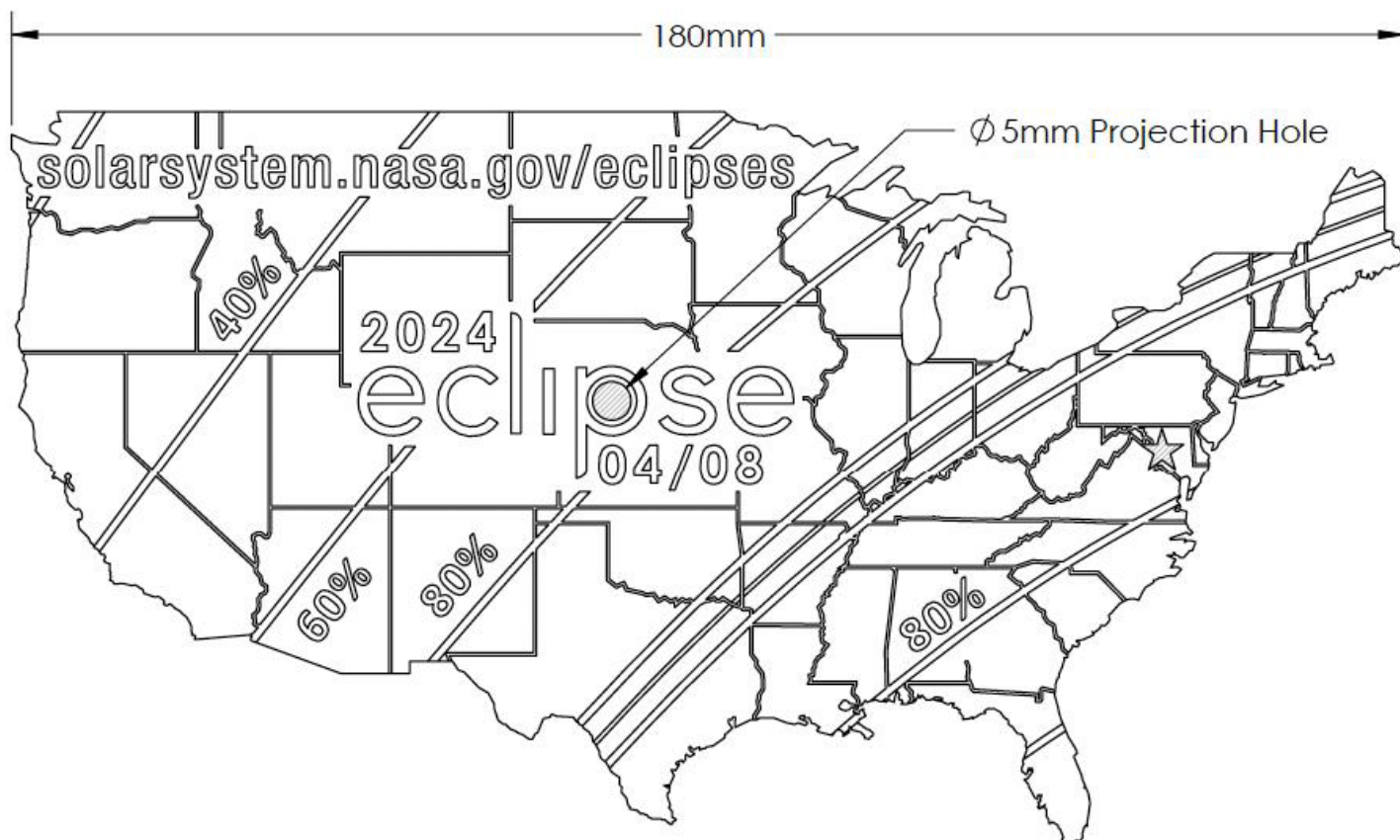


My NASA Data - Lesson Plans

How to Safely Observe an Eclipse



Overview

In this activity students will learn several ways to safely observe a solar eclipse.

Learning Objectives

- Identify and practice safe methods for viewing the Sun
- Identify the different types of solar eclipses
- Examine eclipse data to determine what they will experience during the 2023 and 2024 solar eclipses
- Make a plan for safely viewing the upcoming 2023 and 2024 solar eclipses
- Calculate the diameter of the Sun using data collected from a pinhole projector

Why Does NASA Study This Phenomenon?

"Studying the innermost part of the corona – visible only during total solar eclipses – is key to

answering fundamental questions about how heat and energy are transferred from the Sun out into the solar wind, the constant stream of particles that the Sun spews into the solar system. The solar wind can impact humans and technology at Earth, so understanding how it becomes accelerated at the Sun can help predict its impacts at home."

Learn more at [NASA Eclipse Science](#).

Source:

NASA Research | Science. (n.d.). NASA Solar System Exploration. Retrieved February 26, 2023, from <https://solarsystem.nasa.gov/eclipses/science/nasa-research/>

Essential Questions

How do we safely observe a solar eclipse?

Materials Required

Materials:

- Print Student Sheets
 - How to Safely Observe a Solar Eclipse Student Sheets [Google Doc](#) OR How to Safely Observe a Solar Eclipse Student Sheets [PDF](#)
 - [2023 US Annular Eclipse Map and 2024 US Total Eclipse Map](#) (cardstock, recommended)
- Scissors
- Hole Punchers, 5mm recommended
 - Circle
 - Star
 - Other shape, i.e. square, triangle, heart
- [Eclipse Safety Quiz Google Form](#)
- Optional: solar eclipse glasses
- Optional: regular sunglasses
- Optional: 3D print 2023 US Annular Eclipse Map and/or 2024 US Total Eclipse Map
 - [2023 Annular Solar Eclipse - USA Map - NASA Pinhole Projector File](#)
 - [2024 Total Solar Eclipse - USA Map - NASA Pinhole Projector](#)

Teachers who are interested in receiving the answer key, please complete the [Teacher Key Request and Verification Form](#). We verify that requestors are teachers prior to sending access to the answer keys as we've had many students try to pass as teachers to gain access.

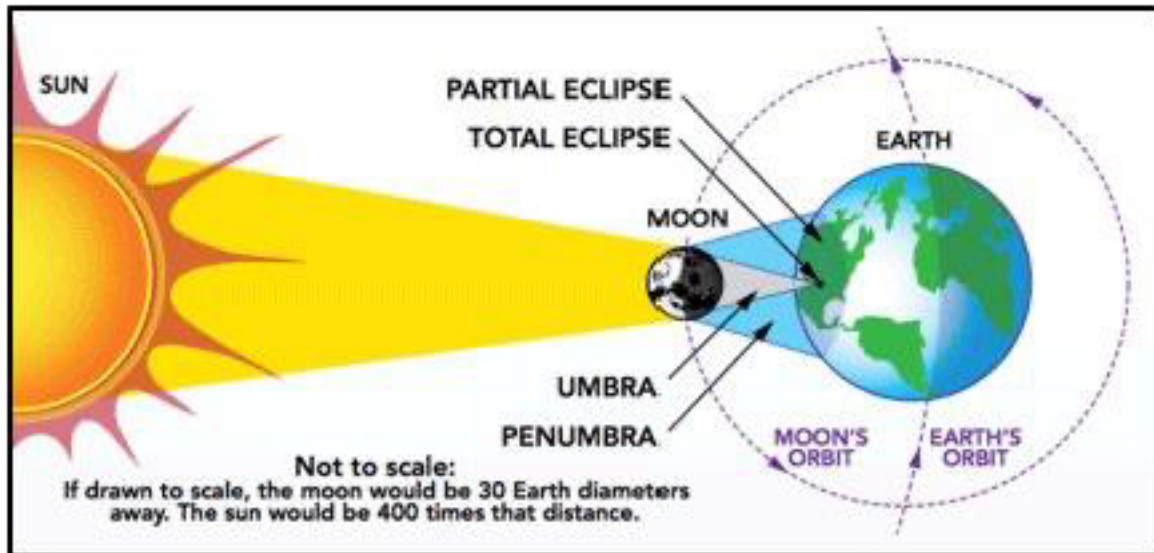
Procedure

Remember to never look directly at the Sun without proper safety equipment.

Steps:

- 1. Gather Background Knowledge:** A solar eclipse occurs when the Moon is between the Sun and Earth, and with the right conditions, the Moon casts a shadow on Earth's surface.

Observers experience different types of solar eclipses, depending on what part of the Moon's shadow the observer is in.



Umbra and penumbra, Image Credit: NASA

Position of Sun, Moon and Earth during a solar eclipse. https://mynasadata.larc.nasa.gov/sites/default/files/inline-images/Umbra%20and%20penumbra%202_0.png, Credit: NASA The phenomenon of a solar eclipse is possible because even though the Sun is about 400 times larger than the Moon, the Sun is about 400 times farther away from Earth than the Moon is. This ratio of the size and distance of these objects makes them appear the same size in the sky.

Have the students watch the [Solar Eclipse Animation](#).

Solar Eclipse Animation | Video Length 0:30 | Credit: NASA's Goddard Space Flight Center Conceptual Image Lab

To experience a **total solar eclipse**, the observer must be in the umbra shadow of the Moon. The path of the umbra shadow across Earth is called the “**path of totality**.”

During a solar eclipse, people in locations in the path of totality will experience 2-4 minutes when the shadow completely blocks out the light from the Sun. We call this a total solar eclipse. This is the only time when viewers can remove their solar eclipse glasses.

People who are outside the path of totality, will see a **partial solar eclipse**, where only part of the Moon's shadow covers the Sun. Solar eclipse glasses are needed to view a partial solar eclipse. People in different locations will experience different percentages of coverage of the Sun by the Moon's shadow.

A third type of solar eclipse happens when the Moon is farther away in its elliptical orbit around the Earth and appears smaller, not completely blocking the disk of the Sun, only about 90%. This is called an **annular solar eclipse**. Because both the Earth and the Moon are moving, on some occasions observers may experience a total and an annular eclipse in the



Total Solar Eclipse

Annular Solar Eclipse

Partial Solar Eclipse

From left to right, these images show a total solar eclipse, annular solar eclipse, and partial solar eclipse. A hybrid eclipse appears as either a total or an annular eclipse (the left and middle images), depending on the observer's location. Credits: Total eclipse (left): NASA/MSFC/Joseph Matus; annular eclipse (center): NASA/Bill Dunford; partial eclipse (right): NASA/Bill Ingalls

https://my NASA data.larc.nasa.gov/sites/default/files/inline-images/Eclipse%20type%20images_0.png

- Examine Data:** The United States will experience all three types of solar eclipses in the coming years! There will be an annular solar eclipse on October 14, 2023 and a total solar eclipse on April 8, 2024. Examine the US map below, showing the paths of these two solar eclipses. Just like there is a path of totality for a total solar eclipse, there is a path of annularity for an annular solar eclipse. You must be on the path of annularity to experience what scientists refer to as the “ring of fire.” People experiencing an annular solar eclipse still need to keep their solar eclipse glasses on the entire time. Everyone outside of the paths will



Eclipse Map with Paths of Annularity and Totality, Image Credit: NASA's Scientific Visualization Studio, https://my NASA data.larc.nasa.gov/sites/default/files/inline-images/eclipse_map_1920v2%202023_04_11.png

Click to enlarge map.

2023 Path of Annularity *October 14, 2023*



Along a path about 125 miles wide, the Sun will appear as a “ring of fire” in the sky. Annularity lasts up to 5 minutes depending on the viewer's location within this path.

2024 Path of Totality *April 8, 2024*



Along a path about 115 miles wide, the Moon will completely block the Sun in the sky. Totality lasts up to about 4 minutes and 28 seconds depending on the viewer's location within this path.

Outside of these paths, viewers within the 48 contiguous U.S. states and many other areas will see a partial solar eclipse (in the shaded areas below).

Reading the Map

Inside the paths of totality (100% obscuration) and annularity (90% obscuration) are irregular ovals that delineate the Moon's shadow on the Earth's surface, which is irregular in shape due to the shape of the lunar limb (lunar topography), and the topography and curvature of Earth. On the map, the ovals contain times inside corresponding to the shape of the Moon's shadow cast at that time during the eclipse.

Also within the dark paths are duration contours. These delineate the length of time annularity or totality will last. The closer to the center of the solar eclipse path, the longer it will last. For the annular path, times range from a few seconds on the outer edge to a maximum of around 4.5 minutes in the center. For the total path, times range up to 4 minutes.

Outside the eclipse paths, the map displays contours of obscuration, or percentage of the Sun's area covered by the Moon. Readers can trace the lines to percent obscuration numbers printed along the left and top of map for the 2023 annular solar eclipse (yellow lines) and along the right and bottom for the 2024 total solar eclipse (purple lines). For example, locations on the 80% line will experience a partial solar eclipse, with only 80% of the Sun being blocked.

Analyze the map: Ask students what they will experience at your location during each of these eclipses?

- What is your location?
- Will you be in the path for either eclipse?
 - If so, approximately how long will totality or annularity last at your location?
- If you will experience a partial solar eclipse, how much of the Sun will be obscured at your location for each type of eclipse?

3. Exploring Safe Methods for Viewing the Sun. Always use the proper safety equipment to observe the Sun. Solar filters are 1000 times darker than sunglasses and block all infrared and UV light, and nearly all visible light. If you don't have solar eclipse glasses or a solar filter for your telescope or binoculars, there are **indirect ways** to safely observe the Sun, like using a **pinhole projector**.

Optional: If you have solar eclipse glasses, have students put them on inside. They will immediately experience complete darkness, as the glasses block out nearly all of the light. Have them compare that experience to just regular sunglasses. This is a very effective



Special eclipse glasses can be used to observe a solar eclipse. Regular sunglasses are not safe to view a solar eclipse., Image Credit: NASA, <https://my.nasadata.larc.nasa.gov/sites/default/files/inline-images/eclipse%20glasses%20and%20sunglasses.jpg>

What is a pinhole projector? Pinhole projectors allowed early scientists to view the shapes of illuminated objects, like the Sun, by shining the light from the object through a very small hole, projecting the image onto the ground or a wall. You can use a paper plate or any heavy paper with a small hole punched in it, or you can use a colander, or just your hands!

demonstration at showing how much light the two types of glasses block.

Pinhole projector

A safe way to view the solar eclipse

With your back facing the sun, raise a paper plate with a small hole punched in it.

Aim the beam from the hole onto another piece of cardboard.

The farther away you hold your pinhole, the bigger the projected image will be.



SOURCE: NASA

AP

With your back facing the Sun, raise a paper plate with a hole punched in it. Aim the beam from the hole on another piece of cardboard. The further away you hold the pinhole, the larger the projected image will be. <https://mydasadata.larc.nasa.gov/sites/default/files/inline-images/PInhole%20projector%20times%20union.jpg>, Image Source: Times Union

Safety Reminder: Keep your back to the Sun when using a pinhole projector.



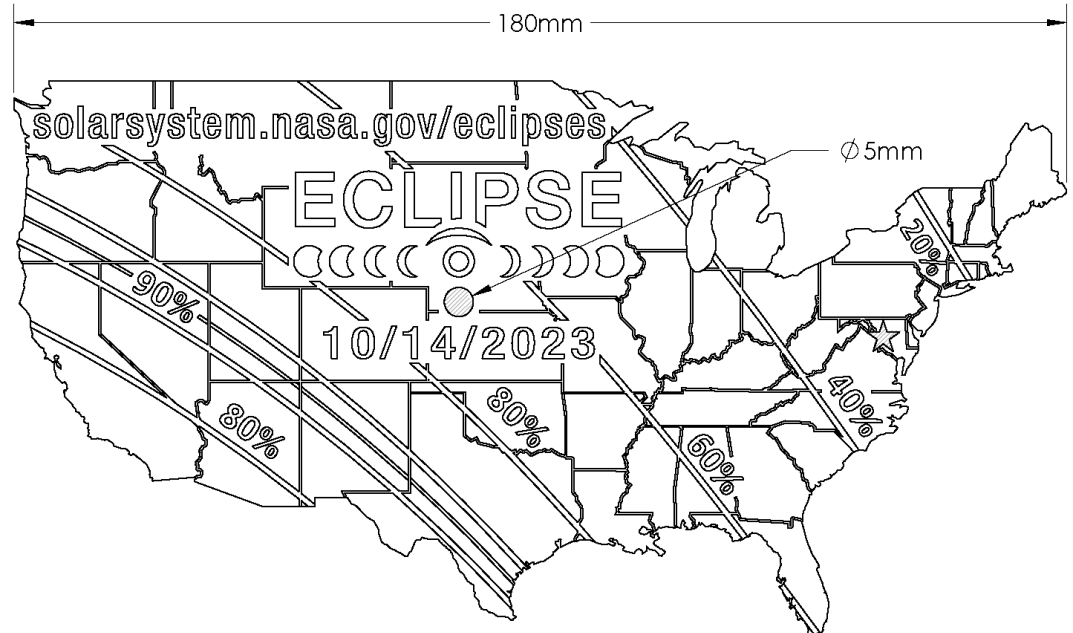
Indirect Viewing Methods: Project images of the Sun using your hands or a colander.

Credit: Left Image: AAS; Right Image: NASA/Joy Ng.

<https://mydasadata.larc.nasa.gov/sites/default/files/inline-images/Indirect%20Viewing%20Methods.png>

4. Get ready for 2023

- 1. 2023 Plan A: Indirect Viewing. Use a pinhole projector to indirectly view the solar eclipse.** This data driven pinhole projector shows how much of the Sun's disk is blocked by the Moon at each location on the map during the October 14, 2023 annular eclipse. For example, locations on the 20% line will experience a partial solar eclipse, with only 20% of the Sun being blocked. In fact, technically, an annular solar eclipse is a partial solar eclipse because at maximum annularity, only 90% of the Sun



US pinhole projector eclipse map for Saturday, October 14, 2023. Credit: NASA/J. Patrick Haas, <https://mynasadata.larc.nasa.gov/sites/default/files/inline-images/USA%20Eclipse%202023%20Pinhole%205mm.png>

- 1. Your back should be to the Sun when using a pinhole projector.**

- Cut out this pinhole projector of the 2023 Annular Solar Eclipse US Map.
- Hole-punch a **circle** in the middle of the map and a **star** over Washington DC.
- Choose **one other shape** and punch a hole where you live.

- 2. Make a prediction:** Have students predict what shape will the Sun be when it is blocked.

- Times not during an eclipse (regular Sun)?
- During a partial eclipse?
- During an annular eclipse?

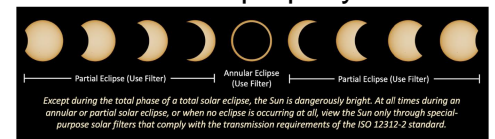
The shape of the hole in a pinhole projector doesn't matter. At times not during an eclipse the Sun will always project as round, no matter what the shape of the hole is in, because the Sun is round. During a partial solar eclipse and an annular solar eclipse, the shape of the Sun will be different, depending on how much of the Moon's disk is blocking the Sun.

Optional:

- See the extensions section of this lesson for a prediction activity
- If you don't want to use the template provided, you can make a pinhole projector from a box as shown in the [How to Make a Pinhole Projector to View the Solar Eclipse video](#).

How to Make a Pinhole Projector to View the Solar Eclipse |
Video Length: 1:05 | Credit: NASA's Goddard Space Flight Center

2. **2023 Plan B: Direct Viewing: Use solar eclipse glasses to directly view the solar eclipse.** Examine the Annular Eclipse Sequence about how to properly use



Annular Eclipse Sequence, <https://my NASA data.larc.nasa.gov/sites/default/files/inline-images/Annular%20Eclipse%20Sequence.png>, Credit: American Astronomical Society

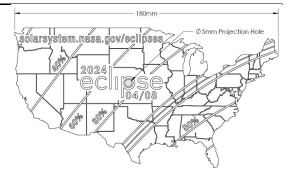
1. Ask students:

- For observers experiencing an annular solar eclipse, when do you need to use solar eclipse glasses?
- For observers on the 90% line (path of annularity)?
- For observers experiencing a partial solar eclipse (80%, 60%, 40%, 20%) during an annular solar eclipse.

5. Get ready for 2024

- (Optional) 2024 Plan A: Indirect Viewing: Repeat the procedure for the pinhole projector of the 2024 Total Solar Eclipse US Map.** This data driven pinhole projector shows how much of the Sun's disk is blocked by the Moon at each location on the map during the April 8, 2024 total solar eclipse. For example, locations on the 80% line will experience a partial solar eclipse, with only 80% of the Sun being blocked. Only observers in the path of totality will experience a total solar eclipse, with 100% of the Sun being blocked.

It should be noted that experiencing 100% totality is much, much different than 95%. Even at 95%, the Moon does not block enough of the Sun to cause the unique conditions that occur during a total solar eclipse, which include significant darkening of the sky, even the appearance of stars behind the eclipsed Sun. These conditions affect the air temperature and animal behavior, who begin to act as if it is nighttime!



A 2D cutout of a USA eclipse map for Monday, April 8, 2024. Credit: NASA/J. Patrick Haas, <https://my.nasadata.larc.nasa.gov/sites/default/files/inline-images/Pinhole%20viewer%20total%20eclipse.png>

1. **Make a prediction:** What will you see using a pinhole projector during totality?

2. **Optional:**

- See the extensions section of this lesson for a prediction activity
- If you don't want to use the template provided, you can make a pinhole projector from a box as shown in the [How to Make a Pinhole Projector to View the Solar Eclipse video](#).

2. **2024 Plan B: Direct Viewing: Use solar eclipse glasses to directly view the solar eclipse. Examine the following graphic about how to properly use solar eclipse**



Progression of a total solar eclipse from partial to total and back to partial. <https://my.nasadata.larc.nasa.gov/sites/default/files/inline-images/Total%20Eclipse%20Images%20to%20map.png> Credit: American Astronomical Society

1. Have students answer the questions.

- For observers experiencing a total solar eclipse, when do you need to use solar eclipse glasses?
- For observers on the 100% line (path of totality)?
- For observers experiencing a partial solar eclipse, near the 100% line, but only at 95%?
- For observers experiencing a partial solar eclipse, on the 80% lines?
- For observers experiencing a partial solar eclipse, on the 60% line?
- For observers experiencing a partial solar eclipse, on the 40% line?

glasses during a total solar eclipse.

6. Have students take quiz to determine if they are ready to safely observe any type of eclipse. Use the [Eclipse Safety Quiz Google Form](#) by making a copy and assigning to your students.



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Sources:

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4. *US eclipse map for Saturday, October 14, 2023*. Credit: NASA/J. Patrick Haas
5. A 2D cutout of a USA eclipse map for Monday, April 8, 2024. Credit: NASA/J. Patrick Haas
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7. *Types | About – NASA Solar System Exploration*. (n.d.). NASA Solar System Exploration. Retrieved April 2, 2023, from <https://solarsystem.nasa.gov/eclipses/about-eclipses/types/>
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9. *2023 Annular Solar Eclipse - USA Map - NASA Pinhole Projector*. (2023, February 13). NASA 3D Resources. Retrieved August 16, 2023, from <https://nasa3d.arc.nasa.gov/detail/usa-eclipse-2023>
10. *2024 Total Solar Eclipse - USA Map - NASA Pinhole Projector*. (2023, February 13). NASA 3D Resources. Retrieved August 16, 2023, from <https://nasa3d.arc.nasa.gov/detail/usa-eclipse-2024>

Extensions

1. Pinhole projection predictions.
 - Print the [Pinhole Projector Prediction sheets](#) and cut them for the students.
 - Distribute the prediction slips to students to make their predictions.
 - Distribute the result sheets to the students to show what they observe.
2. Calculating the Diameter of the Sun with a Pinhole Projector
 - Print the [Calculating the Diameter of the Sun with a Pinhole Projector student sheets](#). Lead students through the calculation of the Sun's diameter and test if possible.